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THE UNITED STATES OF AMERICA

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By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

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Certifying Officer

15750

U.S.PTO

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

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U.S. PTO 22856 00/548106

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TITLE OF THE INVENTION (500 characters max)

AIRCRAFT FUEL TANK AND INERTING SYSTEM THEREFOR

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ENCLOSED APPLICATION PARTS (check all that apply)

☒	Specification	*Number of Pages:* 8	☐	CD(s), Number	
☒	Drawings	*Number of Sheets:* 1	☐	Other (specify)	
☒	Application Data Sheet				

METHOD OF PAYMENT OF FILING FEES FOR PROVISIONAL APPLICATION FOR PATENT

☐ Applicant(s) claims small entity status.

☒ A check is enclosed in the amount of **$160.00** for the filing fee.

☒ The Commissioner is authorized to charge any underpayment or credit any overpayment to Deposit Account No. 25-0120

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No

☐ Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

Docket No.: **3003-1134**

By: Benoit Castel

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Date: **February 27, 2004**

BC/maf

PROVISIONAL APPLICATION FILING ONLY

Y&T February 27, 2004

Application Data Sheet

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Initial 2/27/04

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Initial 2/27/04

Aircraft Fuel Tank and Inerting System Therefor

This invention relates to aircraft fuel tank systems and to methods for inerting aircraft fuel tanks.

Regulations require that the fuel tanks of civil aircraft are rendered inert, that is to say that the flammability hazard posed by the fuel tank is reduced, by maintaining the oxygen concentration below a preset figure – typically 11.9% but can vary from 9% to 12%. It will be appreciated that an inflow of gas into the aircraft fuel tank is required both to make up for the burn rate of the fuel exiting the tank, and also to maintain the pressure differential across the tank within the structural design limits during descent. The mass flow rate required during descent is therefore relatively high as a substantial mass is required to pressurize the tank.

It is known to generate nitrogen-enriched air using an air separation device such as a system using Hollow Fibre Membrane technology to separate air into oxygen and nitrogen and to provide nitrogen-enriched air in which the concentration of nitrogen is greater than ambient air and the concentration of oxygen is lower.

In prior art systems, ambient air is permitted to enter the fuel tanks during descent, and nitrogen-enriched air of sufficient flow and purity is added to the tank to ensure that the overall average oxygen concentration does not exceed the defined limits for an inert tank (typically 11.9% oxygen by volume at sea level). In such systems the nitrogen-enriched air is supplied at a concentration of between 10% to 12% oxygen concentration (by volume) and, when eventually

mixed with ambient air, a typical mixture concentration of 16% to 18% oxygen concentration results.

A problem with this system is that the introduction of ambient air is via the aircraft fuel vent system which is typically designed with the fuel system requirements in mind, and has inlets in only a limited number of locations in the tank. This means that, during the descent phase, air introduced via the vent systems tends to create localised pockets within the tank where the oxygen concentration exceeds the defined limit. In tanks divided into compartments or bays, this can result in an entire bay in which the vent is located exceeding the limit.

There is a need for an aircraft fuel tank inerting system capable of overcoming or mitigating at least some of the disadvantages of existing systems.

Accordingly, in one aspect, this invention provides an aircraft fuel tank system comprising:

at least one aircraft fuel tank;

an air separation means for producing nitrogen-enriched air, and

control means operable to control said air separation means to supply nitrogen-enriched air into said at least one aircraft fuel tank during cruise conditions and to supply nitrogen-enriched air at a higher flow rate during descent, whereby substantially the whole of the mass of gas required to maintain the pressure difference across the walls of the fuel tank below a design threshold is provided by said air separation means.

In this arrangement, during the descent phase, instead of replenishing the tanks with a mixture of ambient air derived from the vent system, in combination

with nitrogen-enriched air from the air-separation device, the air-separation device is operated to provide a high flow rate of nitrogen-enriched air in which the concentration of nitrogen is relatively low.

The term "nitrogen-enriched air" is used in this specification to mean air which has passed through an air-separation device including separation means intended to increase the nitrogen content in the air with a commensurate reduction in the oxygen content.

Although we do not preclude the possibility of inward venting of air into the aircraft fuel tank, in the preferred embodiments the control means controls the air-separation means so that the whole of the mass of the gas required to maintain said pressure difference is provided by said air-separation means.

In the described embodiment, the air-separation means provides in use nitrogen-enriched air having a relatively high concentration of nitrogen when operated at relatively low mass flow rates but with the concentration of nitrogen decreasing at higher mass flow rates.

In the above arrangements, although by operating the air-separation means at higher mass flow rates means that the purity of the nitrogen-enriched air is degraded, in most instances the nitrogen-enriched air supplied from the air-separation means will have a nitrogen concentration which is lower than that of ambient air.

A major advantage of this system is that it does not rely in mixing within the aircraft fuel tanks of ambient air and nitrogen-enriched air and so variations in concentration of the nitrogen across the tank are reduced, thereby reducing localised oxygen-rich pockets.

Preferably, the system includes means for distributing the nitrogen-enriched air at a number of spaced locations in said at least one aircraft fuel tank, thereby in use to reduce variations in concentration of nitrogen within said tank.

The air-separation means may take many forms, but preferably comprises a Hollow Fibre Membrane.

In another aspect, this invention provides an aircraft fuel tank system comprising:

at least one aircraft fuel tank;

means for providing nitrogen-enriched air for delivery into said at least one tank, and

means for distributing said nitrogen-enriched air at a number of spaced locations within said at least one tank.

Preferably, substantially the entire amount of nitrogen-enriched air introduced into the at least one fuel tank is drawn from said nitrogen-enriched air providing means.

In another aspect, this invention provides a method of inerting at least one aircraft fuel tank which comprises operating an air separation device during cruise conditions to deliver nitrogen-enriched air with a relatively high concentration of nitrogen at a relatively low mass flow rate into said aircraft fuel tank, and operating said air separation device during descent conditions to deliver nitrogen-enriched air with a lower concentration of nitrogen and at a relatively high mass flow rate, whereby the air-separation device provides substantially the whole of the mass of gas required to maintain the pressure

difference across the walls of the or each fuel tank within a design threshold.

Whilst the invention has been described above, it extends to any inventive combination of the features set out above or in the following description.

The invention may be performed in various ways, and an embodiment thereof will now be described by way of example only, reference being made to the accompanying drawings, in which:

Figure 1 is a schematic view of a single volume tank incorporating an inerting system in accordance with this invention, and

Figure 2 is a schematic view of a tank divided into inter-connecting bays incorporating an inerting system in accordance with this invention.

Referring to Figure 1, in this embodiment the aircraft fuel tank 10 is connected to a source 12 of nitrogen-enriched air via a control valve 14. The source of nitrogen-enriched air may be any suitable form of air-separation device, typically implementing Hollow Fibre Membrane technology. The fuel tank also includes a vent 16 for outwardly venting gas.

In use, during descent, little or no ambient air is introduced into the fuel tank but instead nitrogen-enriched air is supplied at a sufficient flow rate, at a degraded purity of nitrogen (greater than 11.9% oxygen concentration at sea level) to maintain the fuel tank at sufficient purity to remain within the oxygen concentration limit. It will be appreciated that that, at the beginning of the descent phase, the tank will have a relatively high purity of nitrogen due to the build up of nitrogen-enriched air during the cruise condition. During the descent phase the flow rate and purity of the nitrogen-enriched air from the source 12

may typically be approximately equivalent to that of the mixture of nitrogen-enriched air and ambient air supplied in the prior art systems. A major advantage of the present system is that the inflow of gas into the fuel tank is substantially homogenous, thereby reducing the possibility of oxygen-rich pockets.

The supply of nitrogen-enriched air may then be distributed to multiple locations within the tank to reduce the size, duration and oxygen concentration of the local pockets at the distribution outlets at which oxygen concentration exceeds 11.9%.

During the ascent phase, where the reducing external pressure causes the gas within the tank to expand, the expanding gas may exit through the vent system 16, without additional control valves or system logic.

Due to the characteristics of a Hollow Fibre Membrane separator, the weight of the inerting system is not significantly changed in the described system as compared to prior art systems.

The system of Figure 1 may be used where there is just one aircraft fuel tank or where there are multiple tanks.

Referring to Figure 2, this shows an arrangement where there is a single tank which has a series of inter-connected bays 18. Again, there may be other similar tanks connected to the same source 12 of nitrogen-enriched air. Here a flow distribution pipe 20 distributes the nitrogen-enriched air into each of the bays to effect distribution to multiple locations.

Claims

1. An aircraft fuel tank system comprising:

at least one aircraft fuel tank;

an air separation means for producing nitrogen-enriched air, and

control means operable to control said air separation means to supply nitrogen-enriched air into said at least one aircraft fuel tank during cruise conditions and to supply nitrogen-enriched air at a higher flow rate during descent, whereby substantially the whole of the mass of gas required to maintain the pressure difference across the walls of the fuel tank below a design threshold is provided by said air separation means.

2. An aircraft fuel tank system as claimed in Claim 1, wherein said control means controls the air separation means such that the whole of the mass of gas required to maintain said pressure difference is provided by said air separation device.

3. An aircraft fuel tank system as claimed in Claim 1 and Claim 2, wherein said air separation means in use provides nitrogen-enriched air having a relatively high concentration of nitrogen at relatively low mass flow rates, with the concentration of nitrogen being lower at higher mass flow rates.

4. An aircraft fuel tank system as claimed in any of the preceding Claims, including means for distributing the nitrogen-enriched air at a number of spaced locations in said at least one aircraft fuel tank, thereby in use to reduce variations in concentration of nitrogen within said tank.

5. An aircraft fuel tank system as claimed in any of the preceding Claims, wherein said air separation means comprises a Hollow Fibre Membrane.

6. An aircraft fuel tank system comprising:

at least one aircraft fuel tank;

means for providing nitrogen-enriched air for delivery into said at least one tank, and

means for distributing said nitrogen-enriched air at a number of spaced locations within said at least one tank.

7. An aircraft fuel system as claimed in Claim 6, wherein said substantially the entire amount of nitrogen-enriched air is drawn from said providing means.

8. A method of inerting at least one aircraft fuel tank which comprises operating an air separation device during cruise conditions to deliver nitrogen-enriched air with a relatively high concentration of nitrogen at a relatively low mass flow rate into said aircraft fuel tank, and operating said air separation device during descent conditions to deliver nitrogen-enriched air with a lower concentration of nitrogen and at a relatively high mass flow rate, whereby the air-separation device provides substantially the whole of the mass of gas required to maintain the pressure difference across the walls of the or each fuel tank below a design threshold.

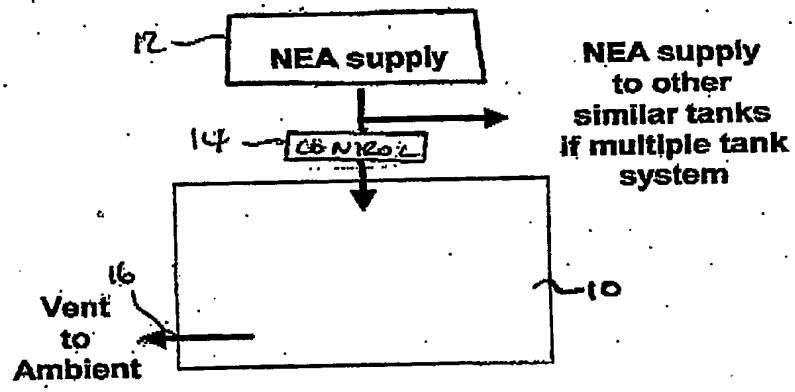

Figure 1
Single Volume Tank

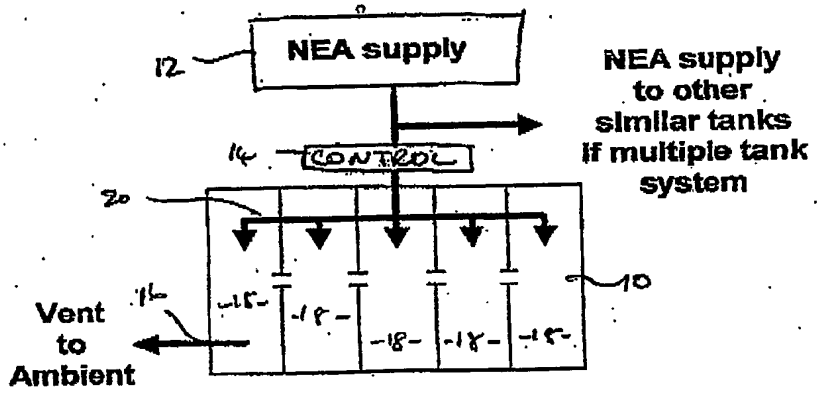

Figure 2
Tank with Bays